

BRS A702 CL: new early-maturing irrigated rice cultivar with herbicide tolerance

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Abstract: *The early-maturing irrigated rice cultivar BRS A702 CL was developed by Embrapa in partnership with BASF for the Clearfield Production System of irrigated rice in the tropical region of Brazil. In the states of Tocantins and Roraima, BRS A702 CL produces a mean yield of 7,650 kg ha⁻¹.*

Keywords: *Oryza sativa L., grain yield, genetic improvement, clearfield production system.*

INTRODUCTION

For the state of Tocantins, the irrigated rice agribusiness plays a major role in foreign exchange and employment generation (Fragoso et al. 2013). The state is the third largest rice producer in Brazil, and is estimated to produce about 619,000 tons of paddy rice on an acreage of 130,000 hectares in the 2016/2017 growing season (CONAB 2017). An irregular rainfall distribution associated with the inclusion of new cultivation areas and an intensified control by environmental agencies have restricted water extraction from rivers for crop irrigation in this state. This forces farmers to adapt their cultivation systems, in the search for more efficient ways to use water, alternatively to the conventional flood irrigation throughout the cycle.

Rice management on waterlogged soil, locally known as “várzea úmida” areas, is the best alternative to deal with limited water availability, because it has the highest environmental efficiency by reducing water use, aside from lower cultivation costs for farmers by decreasing expenses with pumping. However, in this system, weed infestation seriously limits yields (Santos et al. 2015). In addition, as rice is cultivated in the rainy season, between October and March, delays in herbicide application are common, reducing the product effectiveness. Thus, the planting of rice cultivars resistant to a broad-spectrum herbicide, e.g., Kifix[®] of the chemical group of imidazolinones, which also affects red rice, is extremely important to make this cultivation system viable.

In the state of Roraima, rice agribusiness plays a vital role in the generation of employment and income and for the Gross Domestic Product (GDP), and is one of the few effectively established productive chains in the state. Most of

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the production (80%) is exported to other states, mainly to Amazonas, and the rest (20%) is enough to supply the state. The estimated state production in the 2016/2017 growing season on a 12,000 ha area is expected to reach 86,000 tons of paddy rice (CONAB 2017). The use of herbicide-resistant rice cultivars will greatly benefit the rice farmers in this state, where part of the production occurs in “várzea úmida”, which are areas prone to weed infestation (Cordeiro and Medeiros 2010).

The objective of this study was to describe the method used to breed cultivar BRS A702 CL and to describe its agronomic and morphological characteristics. This cultivar was developed by Embrapa in partnership with BASF and is recommended for cultivation using the Clearfield (CL) Production System of irrigated rice in the states of Tocantins and Roraima. BRS A702 CL is the first short-cycle herbicide-tolerant cultivar developed especially for the tropical region of Brazil.

BREEDING METHOD

Cultivar BRS A702 CL was developed by a backcross program between commercial cultivar BRS Formoso (recurrent parent) and cultivar Cypress CL (donor parent), a tolerance source to herbicides of the chemical group of imidazolinones. Cultivar BRS A702 CL was developed with the objective of combining the good agronomic characteristics of BRS Formoso, e.g., high lodging tolerance, high yield, grains with excellent industrial and culinary qualities, and tolerance to the Kifix® broad-spectrum herbicide of the imidazolinone group. The cultivar was developed by Embrapa Rice & Beans, in partnership with BASF, in Goianira, state of Goiás, by the methodology recommended by Rangel et al. (2018). Apart from the initial crossing, three backcrosses were performed, with individual plant selection in each generation, and the whole transfer process of the tolerance allele was performed in a greenhouse. The seeds of the segregating generations were sown in plastic trays in a greenhouse, and 20 days after plant emergence, herbicide Kifix was applied, at a rate of 180 g of the commercial product per hectare, along with the adjuvant Dash at a rate of 0.5% v/v. Ten days after herbicide application, tolerant plants were identified and transplanted into pots. At flowering, separate backcrossing was performed with the recurrent parent. After progeny tests in the RC3F3 generation, eight homozygous families, carriers of the tolerance allele, were selected. These CL families were evaluated in the 2008/09 growing season for herbicide tolerance and agronomic characteristics in tests in Goianira, GO, to select the five best CL families. In the 2010/2011 and 2011/2012 growing seasons, these families, together with the controls BRS Formoso and BRS Alvorada, were evaluated in VCU (Value for Cultivation and Use) test series in Tocantins and Roraima. In view of its performance, line AB101053 CL was recommended for irrigated rice cultivation in the Clearfield system in Tocantins and Roraima and named BRS A702 CL.

PERFORMANCE CHARACTERISTICS

BRS A702 CL was evaluated in 14 VCU tests carried out in 2010/2011 and 2011/2012 in Tocantins and Roraima. The mean yield of BRS A702 CL was 7,650 kg ha⁻¹, similar to that of the two controls, BRS Alvorada (7,698 kg ha⁻¹) and BRS Formoso (7,293 kg ha⁻¹) (Table 1)

The new cultivar has an early-maturing cycle with medium flowering after 80 days, 16 days earlier than its recurrent parent BRS Formoso (96 days). This characteristic is extremely useful for rice farmers who can stagger harvest dates by growing cultivars with differentiated crop cycles. In this way, the crop can be harvested at the ideal moisture content, ensuring a high-quality product on the entire field (Table 1).

Table 1. Mean grain yield (YLD), mean number of days to flowering (FLO), mean plant height (HGT) and lodging incidence (LOD) of cultivar BRS A702 CL and control cultivars (BRS Alvorada and BRS Formoso) assessed in VCU (Value for Cultivation and Use) test series in the 2010/2011 and 2011/2012 growing seasons

Cultivar	YLD ¹ (kg ha ⁻¹)	FLO (days)	HGT (cm)	LOD ² (1-9)
BRS A702 CL	7,650 ab	80	90 ab	1
BRS Alvorada	7,698 a	96 a	99 a	1
BRS Formoso	7,293 b	96 b	91 b	1
Mean	7,042	80	93	
CV (%)	9.33	1.48	3.81	

¹ Data of 14 tests; six in 2010/2011 and eight in 2011/2012.

² Lodging on a 1 to 9 score scale, where 1 - absence of lodging and 9 - completely lodged plants. (Pinheiro et al. 2009)

Means followed by the same letter are not significantly different at 5% probability by Dunnett (1955; 1964)'s Test.

Table 2. Yield of whole milled grain percentage (WhG), broken grains (BG), total grains (TG), chalky grains (Ch), grain length (L), width (W), L/W ratio, grain type and stickiness (ST) of cultivar BRS A702 CL and controls (BRS Formoso and BRS Alvorada), in VCU tests in the 2010/2011 and 2011/2012 growing seasons

Cultivars	WhG%	BG%	TG%	Ch%	L (mm)	W (mm)	L/W	Grain type	ST ¹
BRS A702 CL	60.64	11.97	72.62	1.97	6.68	2.12	3.16	long fine	Lo
BRS Alvorada	66.00	6.95	72.69	2.42	6.68	2.15	3.10	long fine	St
BRS Formoso	60.28	12.53	72.82	2.21	6.66	2.06	3.23	long fine	SLo

¹ Lo = loose grains; St = sticky grains; SLo = slightly loose grains

The plant height of cultivar BRS A702 CL was 90 cm, statistically equal to that of the two controls, BRS Alvorada (99 cm) and BRS Formoso (91 cm), and highly tolerant to lodging, a fundamental characteristic for a product with high industrial quality (Table 1).

The industrial and culinary grain quality are key traits taken into account for the release of a rice cultivar. Cultivar BRS A702 CL has fine long grains. The milled grains are classified as fine long and have a mean length (L) of 6.68 mm and width (W) of 2.12 mm, with a L/W ratio of 3.16, as well as a vitreous appearance, with low grain chalkiness (only 1.97%). Another important industrial trait is the high yield of whole milled grains (60.64%) and total milled grains (72.62%) (Table 2). After cooking, the grains of cultivar BRS A702 CL are loose and soft, as preferred by Brazilian consumers.

Blast (*Magnaporthe oryzae*) is the main yield-limiting factor for irrigated rice in the tropical region of Brazil. The diversity of *M. oryzae* pathotypes reported so far in Brazil is highest in irrigated rice areas in the Araguaia River Valley, state of Tocantins, Dias Neto et al. (2010) obtained 479 *M. oryzae* monospore isolates, which belonged to 45 different races from seven out of nine pathotype groups (IA, IB, IC, ID, IE, IF, IG). This diversity could explain the rapid resistance breakdown in this region, only two years after cultivar release. With regard to rice diseases, the incidence of leaf and panicle blast, leaf scald and grain spot on BRS A702 CL was low. Even when blast incidence is low, we suggest moderate fungicide application as a complementary control strategy to ensure high yields of the cultivar.

In addition, BRS A702 CL was assessed in tests of distinctness, homogeneity and stability (DHS), required by the Ministry of Agriculture, Livestock and Supply (MAPA) to register and protect a cultivar. Some of the data of the DHS tests are listed in Table 3.

The similarity coefficient between BRS A702 CL and its recurrent parent BRS Formoso was 0.95 (Band coefficient; Lynch 1990). This estimate was based on DNA polymorphism analysis of 4,200 SNP markers, using the Illumina DNA Biochip OSBR, Embrapa, Brazil, distributed on the 12 chromosomes of the species.

BRS A702 CL has several favorable agronomic characteristics, e.g., early maturation, high lodging tolerance, high yield, grains with good industrial and culinary quality, and above all tolerance to the herbicide Kifix®.

SEED PRODUCTION

BRS A 702 CL is registered in the National Register of Cultivars (RNC, registry number No. 34461) and protected by the Ministry of Agriculture, Livestock and Food Supply (MAPA). The Business Office of Embrapa Products and Market in Goiania, in partnership with BASF, will be in charge of the production seed of the cultivar.

To obtain seed with high genetic purity, 100 plants of the cultivar were selected and sown in pots (one plant pot⁻¹). Leaves were sampled for DNA extraction and the plants were harvested individually. The 100 plants were genotyped with

Table 3. Main descriptors of rice cultivar BRS A702 CL

Descriptor	Phenotypic expression
Leaf color	Green
Flag leaf angle	Right
Pubescence of leaf blade	Medium
Leaf: auricle color	Light green
Leaf: ligule color	Colorless to green
Stem length	Medium (72 cm)
Panicle length	Medium (22 cm)
Presence of awn	Absent or very short
Spikelets: glume color	Straw/Golden
Spikelets: bud color	White
Dehulled grain length	Long (6.68 mm)
1000-grain weight	27.1 to 28.5

4,200 SNP markers using a DNA chip (Illumina BeadChip OSBR, distributed on the 12 chromosomes of the species, to obtain DNA polymorphism data throughout the rice genome. The multilocus profile of each plant allowed an estimation of the individual genome recovery rate of the recurrent parent. The nine plants with the highest genome conversion rate (95%) and with an identical multilocus genetic profile were selfed and the progenies evaluated in the field. Seeds of these families were sown in trays and the seedlings transplanted to the field (one seed per pit). All plants of the nine families were rigorously screened to eliminate atypical plants and the seeds were bulk-harvested for seed production.

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